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Theoretical and Experimental Pressure Distribution Through Elliptic Fuel Tank

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1. Abstract

In the current work included the production pressure distribution through moved elliptic fuel tank. The work included two aspects, in the first Finite Element Method with control volume has been created as by ANSYS software.

In the second aspect, experiment model has been constructed to be tested in wind tunnel. The results of both theoretical and experimental aspects show that the distribution of the pressure showed that the increase being observed on the front cover and decayed through the longitudinal shell until reversed to be on the outward direction at the back cover. The comparison both the theoretical and experimental results indicated an accepted difference.

Keywords:- Pressure distribution, Fuel tank.

الخلاصة

يتضمن العمل الحالي دراسة الضغط الموزع الناتج من جريان المائع حول خزان وقود بيضوي الشكل. حيث تضمنت الدراسة جانبين:- الاول، جانب نظري اشتمل تصميم نموذج باستخدام برنامج (ANSYS) بالاعتماد على طريقة العناصر المحددة (Finite Element Method) بواسطة الحجم المسيطر (control volume)، أما في الجانب الثاني، فقد تم تصنيع النموذج عملياً واختباره في النفق الهوائي.

بينت النتائج النظرية والعملية ان الضغط الموزع يظهر اعلى قيمة له عند البداية (الواجهة الأمامية للخزان)، ثم يأخذ بالانخفاض خلال القشرة الطولية للخزان وقبل الوصول الى النهاية تنعكس قيم الضغط لتزداد وصولاً الى الواجهة الخلفية. ووقد اوضحت بالمقارنة بين كلا النتائج النظرية والعملية وجود فروقات مقبولة ومرضية.

الكلمات المفتاحية:- توزيع الضغط، صهاريج الوقود.

2. Introduction

Fuel tank with the fluid flow over the surface have been a topic of research for over a hundred years, for their practical and fundamental importance. Practically it is seen that the fuel tank in ellipses shape are much more uses in many engineering and industrial applications such as the transportation of petroleum products and other tank. The primary aim of this thesis is to study theoretical and experimental, the pressure distribution at the different points of ellipse fuel tank. For this study of air flow of wind tunnel is used, after we designed and tested the model in the laboratory to find the pressure distribution around the external surfaces.

Today the finite element method (FEM) is considered as one of the well-established and convenient technique for the computer solution of complex problems in different fields of engineering: civil engineering, mechanical engineering, nuclear engineering, biomedical engineering, hydrodynamics, heat conduction, geo-mechanics, etc. From other side, FEM can be examined as a powerful tool for the approximate solution of differential equations describing different physical processes and modeling aspects and general features of some Finite Element Programs (ANSYS) will be used (Barkanov, 2001).

In practice, a finite element analysis usually consists of three principal steps:- Preprocessing, Analysis and Post processing (Roylance, 2001).

3. Theoretical Considerations

3.1. Geometric Modeling

The selected case study was a fuel tank type (Serin Turkish-made). Currently used in the petroleum products distribution company to transfer fuel among different provinces. Figure (1) shows the real fuel tank as well as the dimensions of the model with the scaled proportion, be amounted to **(1/10)**.

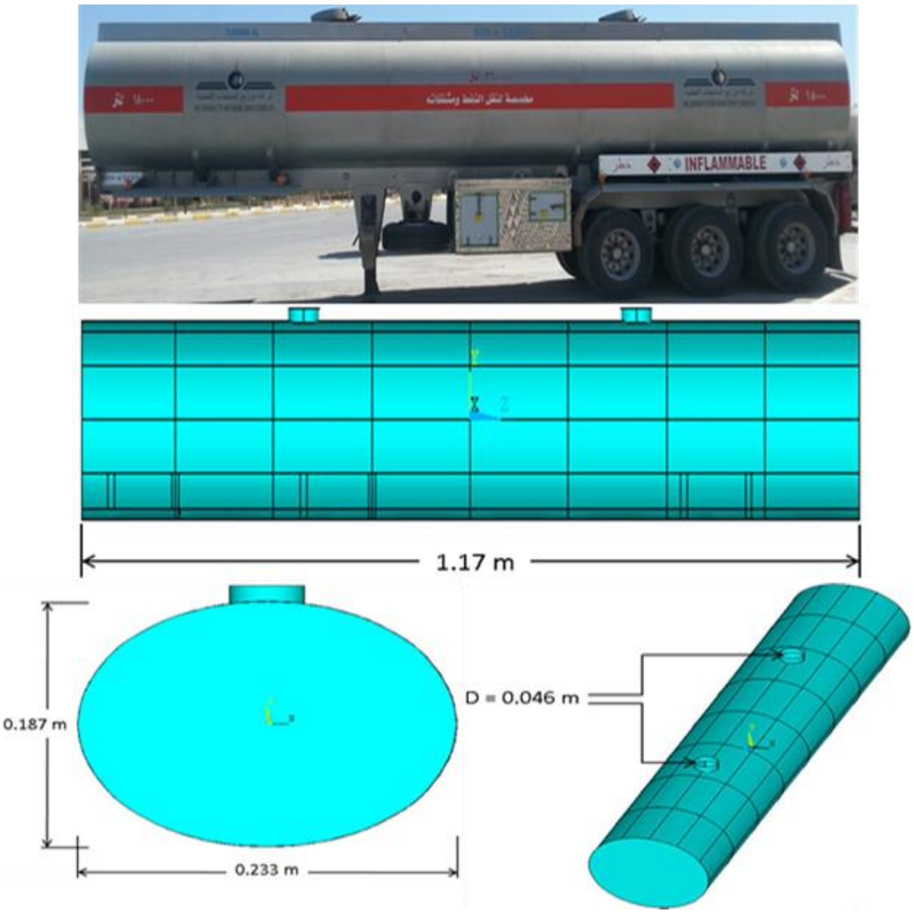


Figure (1):- True fuel tank and the manufacturing model.

3.2. F.E. Model for the Pressure Distribution

The model were designed by using the Finite Element Method (FEM) that depends on the ANSYS software (Version11.0). The element type (3D FLOTRAN 142) was used as appropriate for the fluid-solid interaction analysis.

The model was put in the wind tunnel center, then it worked for the mesh of the air inside the wind tunnel as shown in figure (2), where the maximum velocity of the air inside the tunnel that the model exposed to was (40 m/s).

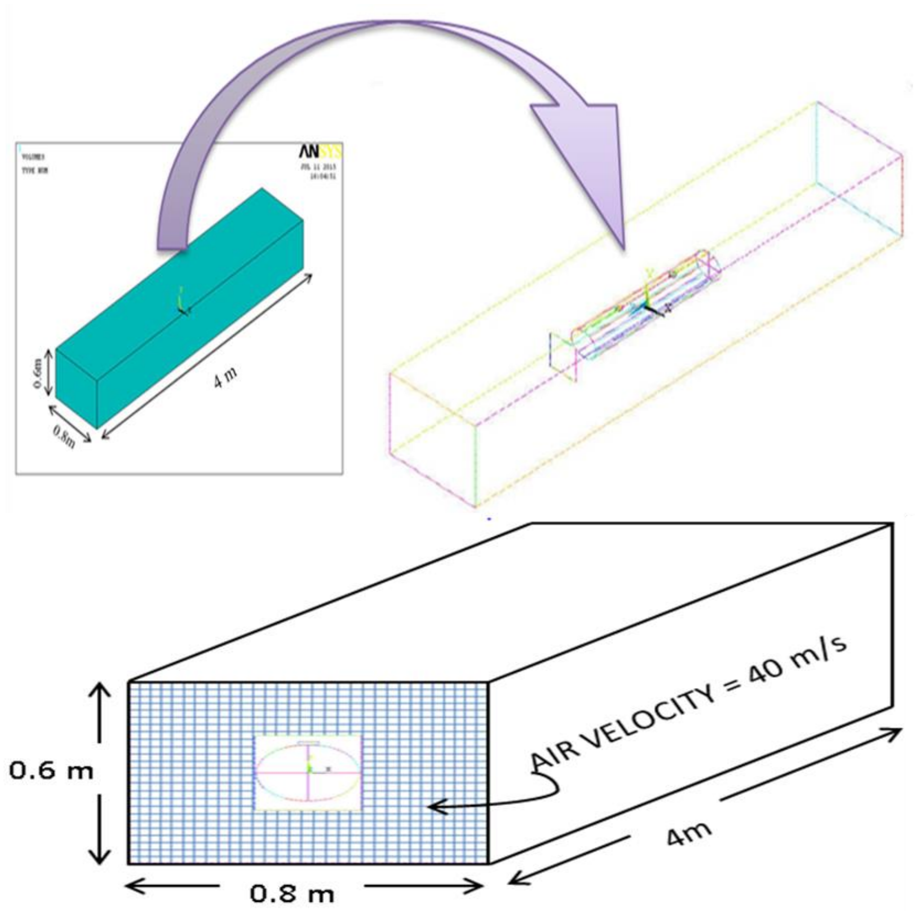


Figure (2):- Mesh work inside the wind tunnel.

3.3. Boundary Conditions

After that, the application of the boundary conditions, includes the followings:-

1. Air velocity entering the wind tunnel is (40) m/s or (144) km/hr.
2. Air pressure that comes out of the tunnel is equal to (0).
3. Air velocity on all the remaining outer surfaces in the wind tunnel is (0).
4. Air velocity on all surfaces of the model inside the tunnel is equal to (0).

After finding the solution for this problem, the results were obtained for the pressure distributor on the outer surface of the model, which was caused by the flow of air around the model. The results were acceptable when the normalized rate of change was (10^{-4}), which represented the convergence of results. This happened after a (731) iteration to resolved in the program as in the diagram (1) below.

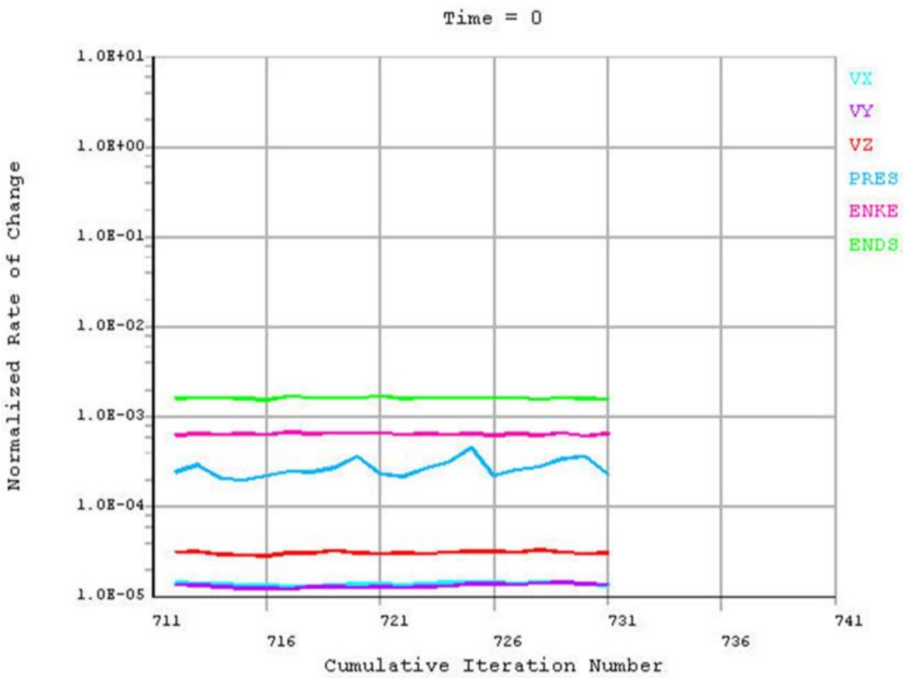


Diagram (1) :- The convergence of results.

The circumference of ellipse model was divided into (12 lines) extended along its length, for the purpose of finding distributing the pressure on the length of each line as shown in figure (3).

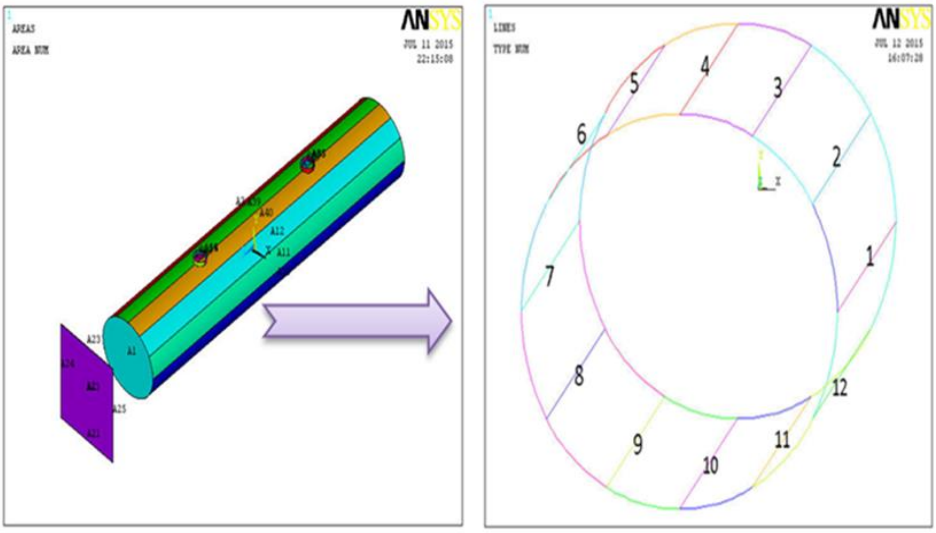


Figure (3) :- The division of model to (12 lines).

4. Experimental Work

4.1. Scaled Structure

A scaled structure has been manufactured using sheet metal of (0.5 mm). The dimensions of the fuel tank were obtained by visiting Oil Products Distribution Company in Babylon to collect the measurements tank type (Serin/Turkish-made) as shown in figure (4) and table (1).

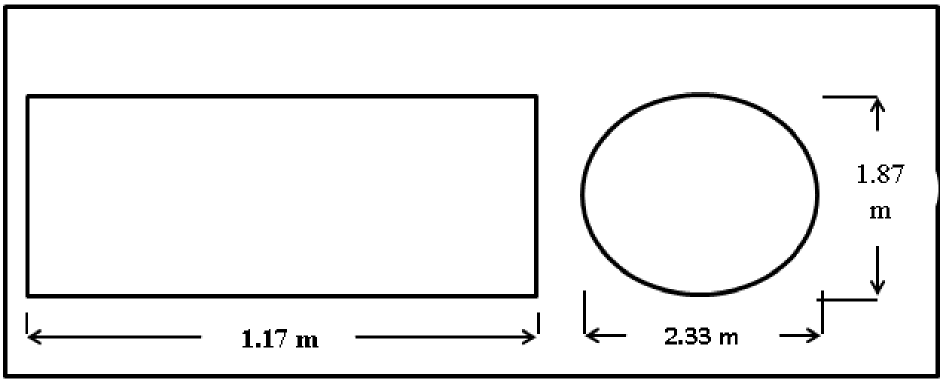


Figure (4) :- Fuel tank type (Serin/Turkish-made).

Table (1):- Dimensions (m) of fuel tank.

Dimensions		M
Length of tank		**11.7**
The diameter of the ellipse section	largest	**2.33**
	smaller	**1.87**
Holes diameter in the top of the tank		**0.46**

The structure was scaled by (1/10) factor so all dimensions were decelerated by this factor as shown in figure (5).

Figure (5):- Scaled structure dimensions.

The scaled shell was mounted on four pairs of axial wheels to fabricate a semi simulation of the fuel tank. Also a truck cabin was mounted on a distance (19 cm) than the front side of the shell as shown in figure (6).

Figure (6):- Scaled structure.

4.2. Mounting of Scaled Structure in the Tunnel

The model was placed at the center of the test section of the wind tunnel as shown in figure (7).

Figure (7):- The model at the center of the wind tunnel.

4.3. Pressure Measurement

The pressure was measured in the locations that are shown in figure (8) by using Pitot tube. The specifications of the Pitot tube that were used are shown in figure (9). The measurement of pressure was synced with the operation of the blower for each locations.

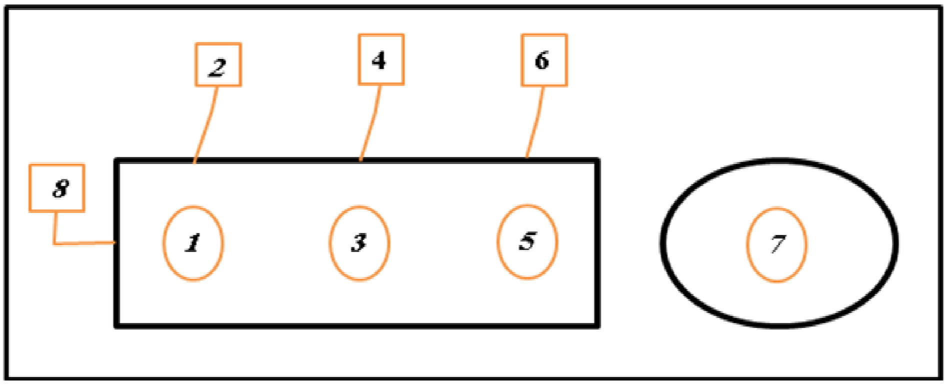


Figure (8):- Locations of the measured.

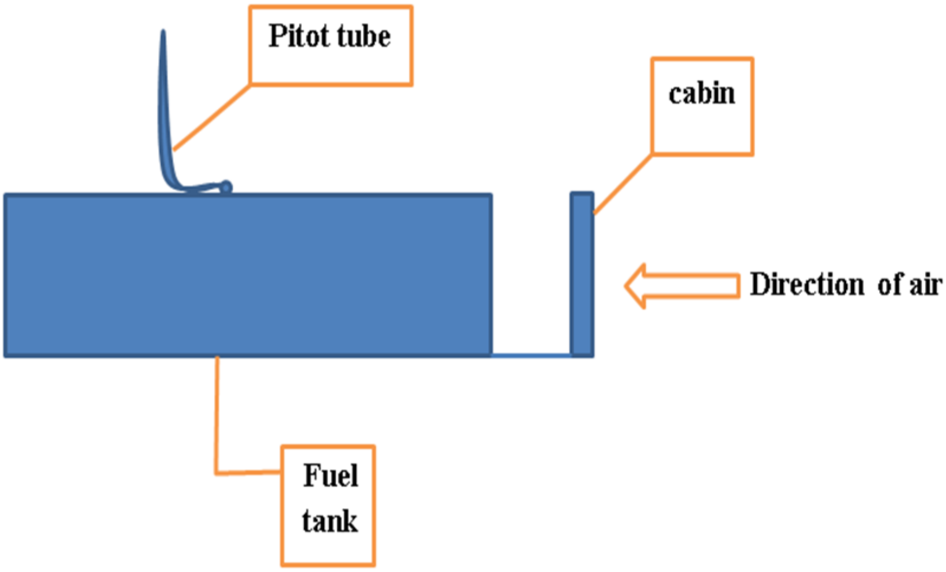


Figure (9):- The measuring the pressure.

Also, figure (10) shows the Pitot tube which was used to measure the pressure over surface of tank.

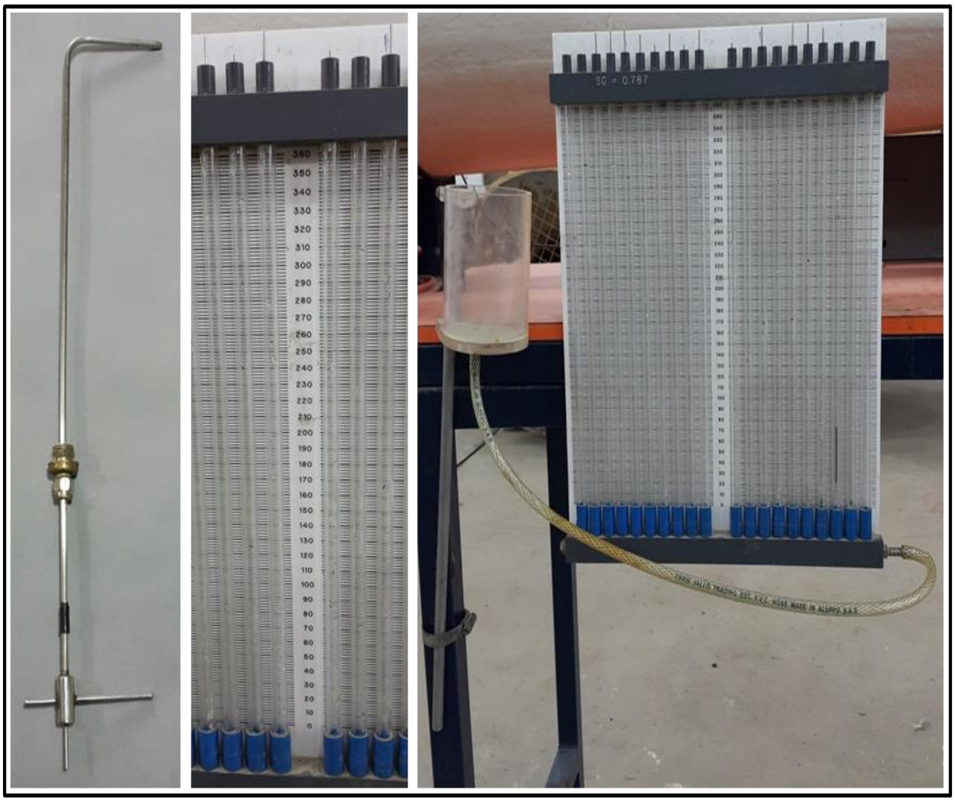


Figure (10):- Pitot tube.

Two lines are specified on the tank as shown in figure (11) to show most of the results that concerned with pressure.

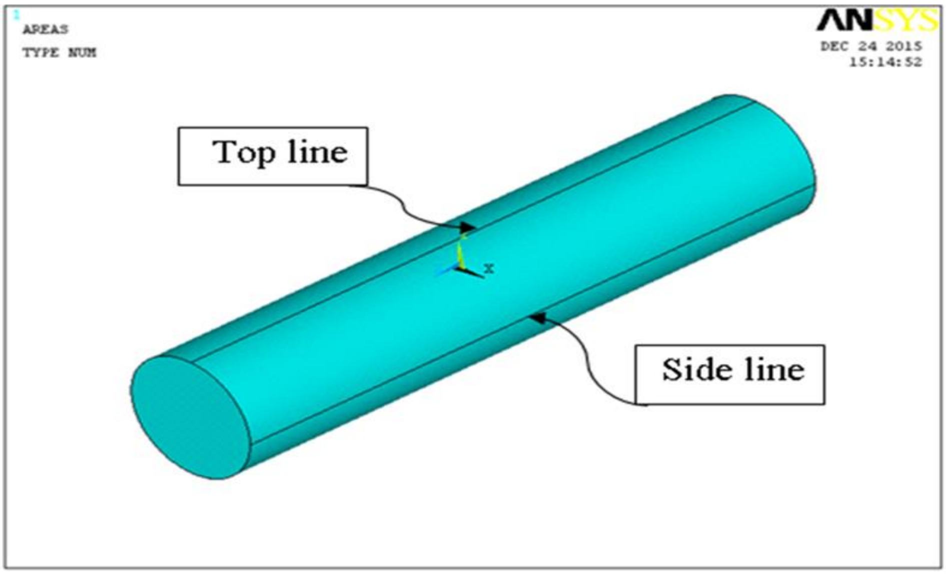


Figure (11):- The specified lines locations.

5. Results and Discussion

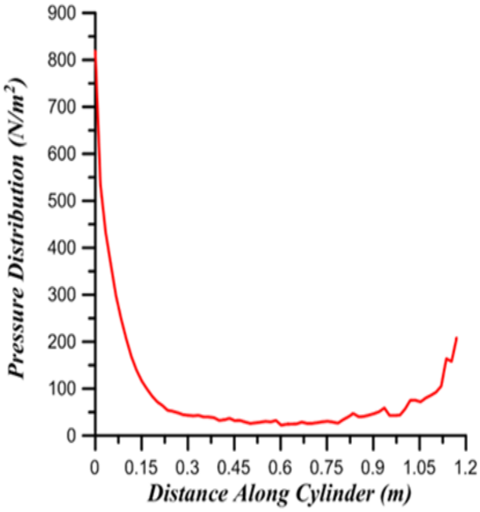
The effect of interaction of air on the outer surface of the elliptical tank is pressure distributed through its surface domain. The pressure distributions were measured experimentally on the selected locations using Pitot tube. Also the pressure distributions were approximately estimated using control volume finite element method. So, a finite element model was created and modeled the air that surrounded to the outer tank surface of dimensions closed the test dimensions of the tunnel. Thus the surrounding (control volume) mesh represented more similar the same air conditions that flows over tank surface. The boundary conditions were assigned so that they represented the velocity of the air that is a verged interact on the outer surface of tank. Figure (12) shows the results of pressure distributions that were estimated approximately from the control volume finite element method using ANSYS software

The distribution of the pressure showed that the increase was observed on the front cover and decayed through the longitudinal shell until reversed to be on outward direction on the back cover. The positive sign of the pressure represented that the direction of the pressure was on inward to the center line of the tank and normal to the tangent of the shell. While the negative sign represented a direction outward from the center of the center line and also normal to the tangent.

The experimental results of pressure distribution on the outer surface inside and the top lines of tank as shown in figure (13). The relation indicated that the pressure distribution values decreased when went to longitudinal over the top and side lines of tank. The experimental values of pressure at the side and top surface were more than (800 N/m^2) to be simulated in the model. It was found that the experimental results were more consistent with the theoretical results.

The effects of pressure anywhere through the surface of tank were passive. The pressure that acted on the longitudinal shell of the tank increases the drag friction then the a waste should be taken into consideration for the engine selection or fuel consumption. The pressure acted on the front cover is passive since its resists the motion of the track and then applies a force depending on the pressure and the area of the cover. The passive effect of the front cover can be minimized by forming the cover as a dome to reduce the effect of the pressure.

When the results of the approximating FEM compared with that obtained experimentally, the comparison indicated a good agreement and reliability. Figure (14) shows the approximation and experimental pressure distribution in the top and side lines. It was also indicated that the maximum error didn't exceed (14%).



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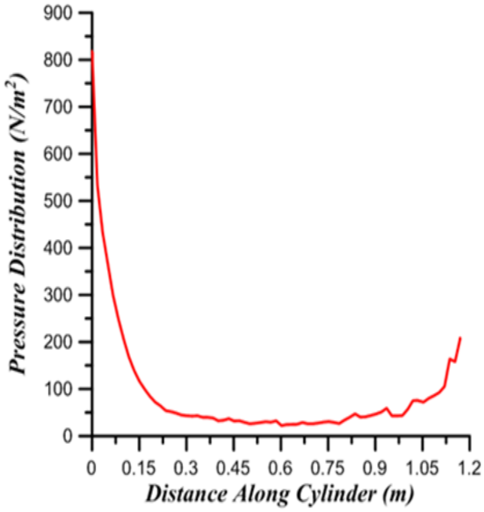

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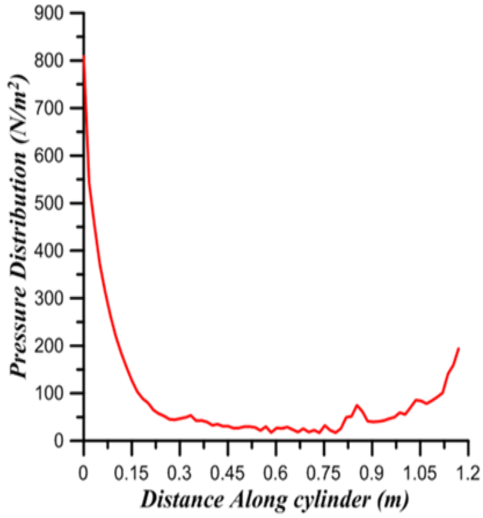

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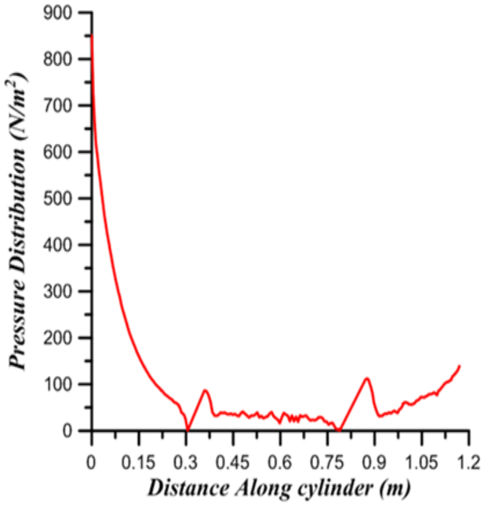

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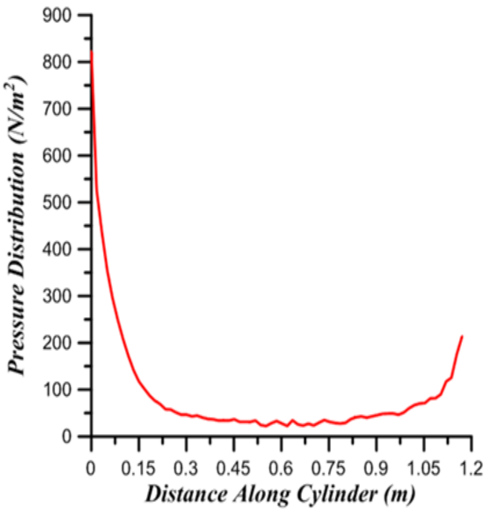

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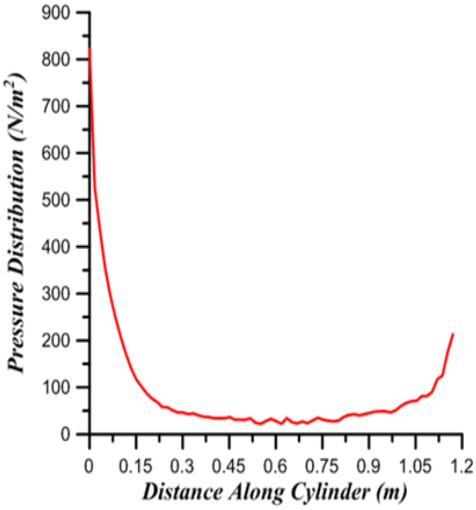

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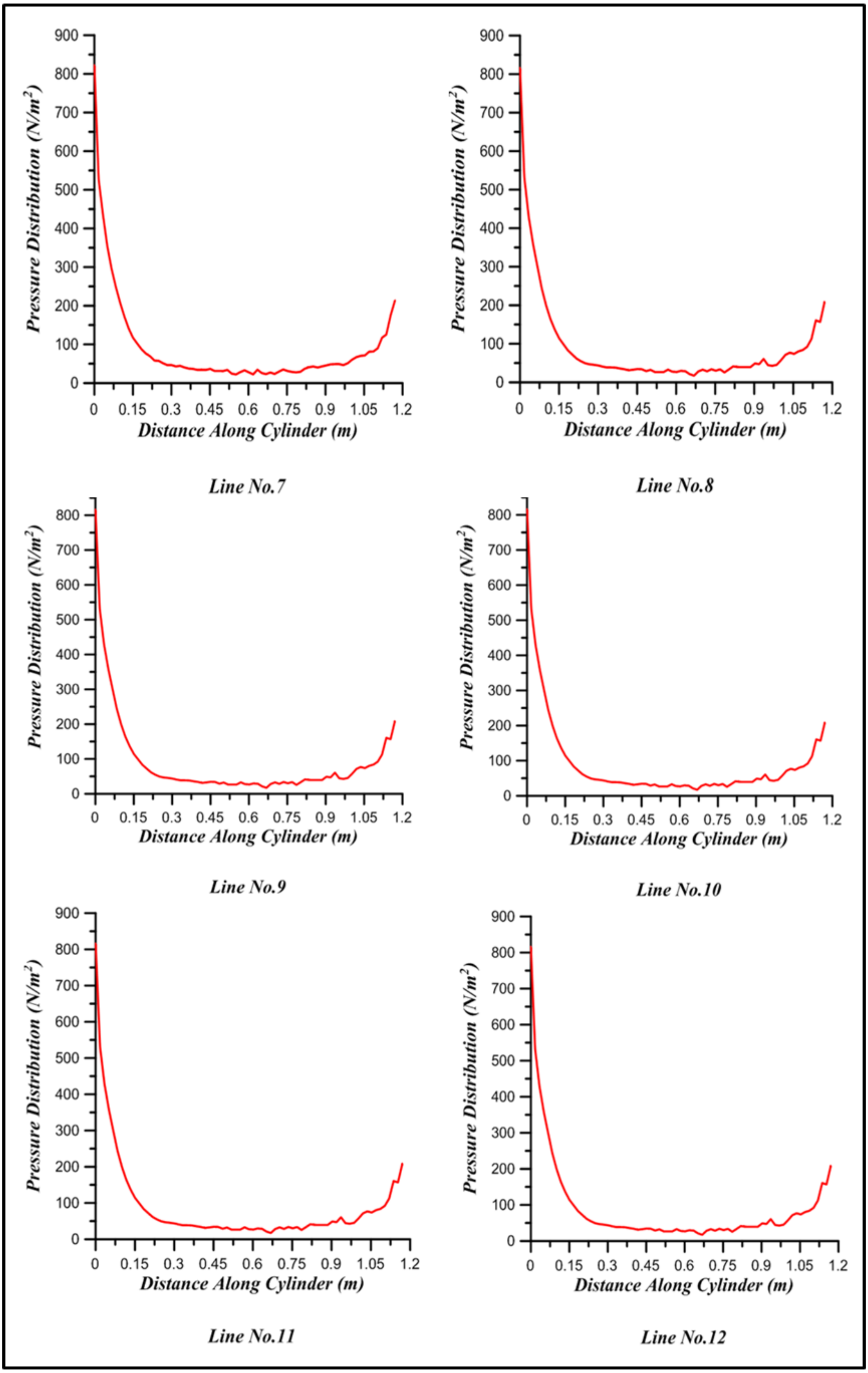

Figure (12):- Pressure distributions estimated using control volume finite element method (Pa).

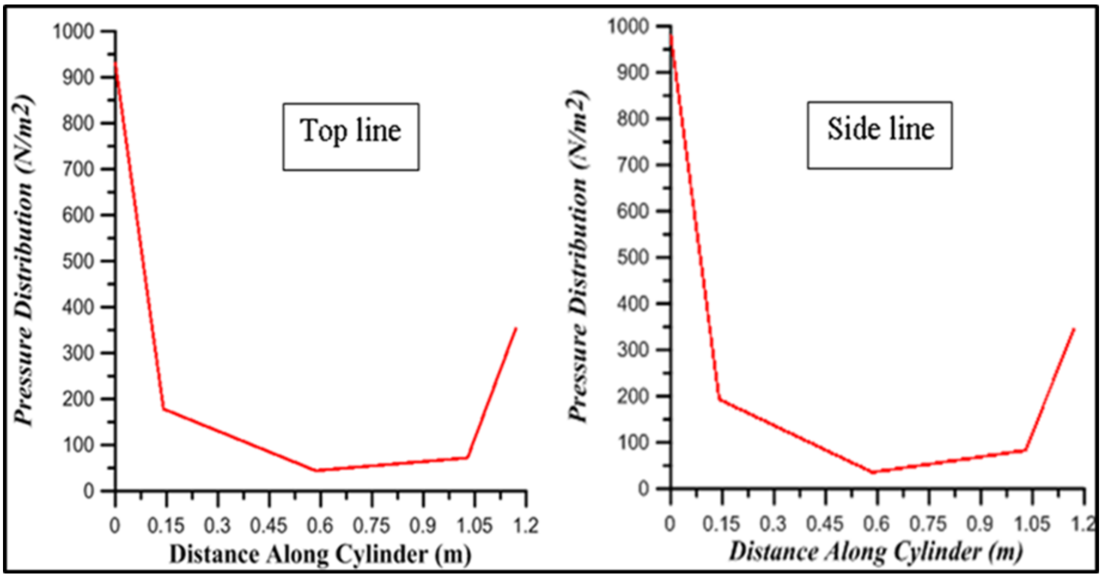

Figure (13) :- The experimental results of the pressure distribution.

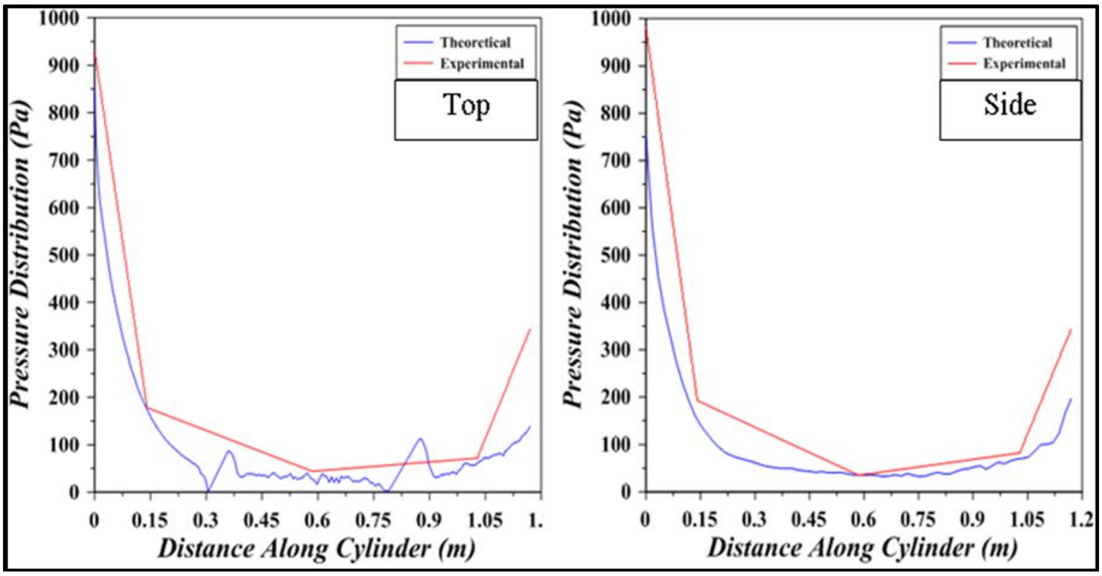

Figure (14):- Approximation and experimental pressure distribution at the side surface of the tank (Pa).

References

ANSYS Release11.0, 2011, *"Documentation for ANSYS"*, ANSYS Help.

Barkanov E., 2001, *"Introduction to the Finite Element Method"*, Institute of Materials and Structures Faculty of Civil Engineering Riga Technical University.

David Roylance D., 2001, *"Finite Element Analysis"*, Department of Materials Science and Engineering Massachusetts Institute of Technology Cambridge, MA 02139.